RACTURES

OF THE

END OF THE RADIUS

ETC. ETC.

Dr GORDON

FRACTURES

OF THE

LOWER END OF THE RADIUS

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A TREATISE

ON THE

FRACTURES OF THE LOWER END OF THE RADIUS

ON

FRACTURES OF THE CLAVICLE

(AND THEIR TREATMENT BY A NEW CLAVICULAR APPARATUS)

AND ON THE

REDUCTION OF THE RECENT INWARD DISLOCATIONS OF THE SHOULDER JOINT

(BY MANIPULATION)

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DEDICATION.

TO THE

MEDICAL STUDENTS OF QUEEN'S COLLEGE, BELFAST.

GENTLEMEN,

The object in view in the publication of the present treatise is to afford you the means of studying carefully these three common accidents. I have very great pleasure in dedicating it to you as a *souvenir* of that mutual respect and esteem engendered during the collegiate life, and to which our memory often reverts afterwards with pleasure.

You may be very attentive at lecture, and your perception of many of the leading facts may be sufficient to enable you to have a tolerably comprehensive and accurate conception of them, yet, if I may judge from the history of the past, it will require on your part the most careful study of the facts laid before you, as they point to an almost complete change in theory and practice.

You have often urged me to publish; I assented and still delayed, as there were many points which in my opinion required further elucidation. I perceived dimly that something was wanting, notwithstanding the time and attention bestowed, as well as the cautious self-examination exercised in my investigations. I was dissatisfied with the explanation usually given as regards the mechanism of Colles's fracture. That a force received on the palm of the hand, and transmitted through the carpus to the carpal surface of the radius, could produce a fracture in a direction almost at right angles to it, seemed to me so strange and incomprehensible that I regarded the explanation as untenable.

It was reserved for the past session (1874-75) to prove, by experiment, that the fracture was the result of an action which mechanics call "a cross-breaking strain," or from forced extension of the hand.

A comparison of the facts contained in this treatise with those of other surgical authors on the same subjects, suggests thoughts which must be of the highest moment to you who are about to enter, or have entered, on the onerous and responsible duties of the practice of your profession.

Accurate observation is necessary to elicit facts, but to theorize upon them is often fallacious, leading to the gravest mistakes, which may be perpetuated for ages.

Dupuytren, observing that the styloid process was elevated, and the lower fragment displaced outwards in fractures of the lower end of the radius, may be said to have reasoned thus: By adducting the hand

I will bring down the styloid process and restore the natural aspect of the carpal surface. He overlooked, however, the fact that the carpus moves outwards in adduction, and is applied against the styloid process, and puts the abductors and other muscles in a state of tension, enabling them to displace the lower fragment outwards upon the upper. From this false theory the pistol splint must undoubtedly have had its origin.

Now, when we reflect on the matter, and additional facts have been elicited, we see plainly the reasons of the failure. I have thus laid before you an instance in which an imperfect practice has resulted from too limited a view of the true nature of the accident, or has been based on one instead of many facts. These facts, when we know them, appear so simple that we are surprised that they should have been so long unrecognized. The facts were known, but their practical bearing was overlooked.

You have often told me of the many strange ways in which you have seen my radial splint applied. This treatise will place matters in their true light, and I have no fear of the result. I must confess that the students of Queen's College, Belfast, have always borne testimony to its merits, and have uniformly adopted it. The only change necessitated in its construction by recent facts was an increase in the curve of the ulnar portion and back splint, for maintaining the hand well flexed during the treatment.

It is more than two years since my observations on fractures of the clavicle were written. I have

nothing to retract or amend, but, on the contrary, the more I reflect upon them the more thoroughly am I convinced of their accuracy. The clavicular apparatus, I confidently affirm, will soon come into general use; and could elevation of the shoulder be prevented, I should consider it perfect.

The reduction of the recent inward dislocations of the shoulder-joint by manipulation has been practised by many of you and myself with such success that in a very short time it will supplant that by violent extension.

It would be ungrateful in me not to express my gratitude to my colleague, Doctor Redfern, Professor of Anatomy, for the great assistance always most generously afforded in my investigations.

I hope ere long to be able to lay before you my views on fractures of the upper end of the femur, of the humerus, and of the leg.

I have the honour to be, Gentlemen,

Your obedient Servant,

ALEXANDER GORDON.

1, HOWARD STREET, BELFAST,
September, 1875.

FRACTURES

OF THE

LOWER END OF THE RADIUS.

FRACTURES of the lower extremity of the radius present several distinct forms which require careful discrimination for correct treatment.

First.—Colles's fracture, in which the lower end of the radius is wrenched off by a "cross-breaking strain," displacing the lower fragment backwards and outwards, with alteration of the aspect of its carpal surface.

Second Form.—The radius is broken an inch or more above its lower end. The fractured ends are displaced backwards and inwards, producing a well-marked prominence on the back of lower part of forearm, with an increase of the concavity of the radius.

The Third Form, or Articular Fracture.—The fragment broken off contains the entire carpal surface, the styloid process, supinator ridge, and a small portion of the compact tissue of the anterior surface of the radius. This fragment is displaced upwards, forwards, and outwards.

There are other forms, but my practical experience of them has been too limited, and I therefore leave to future observers to point out their characters, diagnostic signs, and appropriate treatment.

COLLES'S FRACTURE.

Fractures of the lower end of the radius are now generally admitted to be more frequent than any other fracture. Mr. Colles was the first to describe the most common form of these fractures, hence the term "Colles's Fracture"; but in strict justice to Mr. Colles, to subsequent observers, and to surgical science, the term Colles's Fracture must be restricted to the form or variety which he has described.

Dr. R. W. Smith says: "In by far the most common form of this fracture, the lower fragment is displaced backwards. In this country the name of an eminent surgeon, lately deceased, has been associated with this injury. We know it here as Colles's fracture of the radius." *

SIGNS.

No accident is more easily diagnosed than Colles's fracture. The appearances are so characteristic, that when once seen they can be very easily recognized afterwards. The history is that of a fall upon the palm of the hand. The patient suffers such severe pain, that he immediately supports the injured arm with the opposite hand, and holds it

* Smith on "Disloc. and Fract. in the vicinity of Joints," page 129.

midway between pronation and supination. On examination, we observe the axis of the hand directed unnaturally outwards, the lower end of the ulna prominent, the back of the hand seems elongated and as if prolonged into the fore-arm, ending in a well-marked sulcus; it also projects very much backwards, and the backward projection consists of the base of the metacarpus, the carpus, and the lower fragment of the radius. On the palmar surface of the lower part of the fore-arm is a well-marked swelling, prominent externally, but disappearing when it reaches the ulna. At this stage the student should compare the limb with that of the opposite side, by the application of a straight piece of wood to the back and outer surfaces of each limb. He will thus see that the hand is displaced much further backwards and outwards than the appearances would have led him to suppose. Any attempt at pronation or supination will be resisted on account of the severe pain produced. Acute pain is also experienced from pressure on the seat of fracture, either in front or behind, and in cases where the fracture is near the lower end of the radius, with very little deformity, a correct diagnosis may be arrived at from this sign alone, as a fall upon the palm of the hand could not cause pain along the posterior surface of the radius, unless the bone was broken. In such cases there will be an absence of those signs which usually attend a direct contusion.

SEAT AND FORM OF FRACTURE.

In twenty-seven old specimens the seat of fracture behind was in ten at 1 inch or under; ten were more than 1 inch but not over 1¾-inch. The remaining seven were undefinable, but would all come under either the first or second division. Therefore, according to these twenty-seven specimens, all the fractures occurred posteriorly in the space, from ⅜-inch to 1¾-inch above its carpal border behind. The seat of fracture anteriorly varied from ⅜-inch to 2 inches, and in only one was it as high as 2 inches from the carpal border. It must be remembered that in old specimens there is shortening of the posterior surface of the radius, and, therefore, the measurement taken from the posterior margin of the carpal surface would be greater in recent cases.

Is the fracture transverse? Of the twenty-seven specimens nineteen are oblique from before backwards, and eight directly transverse. It is very doubtful, if these instances of transverse fracture had been examined immediately after the accident, if they would have been considered directly transverse; and there can be no doubt, from the evidence afforded, that the fracture is higher behind than in front. The fracture is, therefore, usually oblique from before backwards.

Fig. 1 is taken from an old specimen, and shows a wide gap between the fragments in front. The fracture is transverse from within outwards, until arriving at the anterior border of the supinator

ridge, when it suddenly ascends one third of an inch, then crosses obliquely downwards and inwards. The lower end of upper fragment projects forwards, and is broken obliquely from before backwards, whilst

FIG. 1.

the lower fragment is concave from within outwards, and is displaced backwards, outwards, and slightly upwards. The inner prominence on the palmar surface of the radius has been rotated so much backwards as to be on a level with the plane of the shaft of the radius. How could this displaced fragment be replaced so as to restore the normal form of the radius? By extension and flexion of the hand to an angle of 45°, a careful study of this specimen should be sufficient to point out the true principles of treatment.

A very common course of the line of fracture is transverse from within outwards, until it reaches the ridge on the outer margin of the radius, when suddenly ascending it crosses the upper end of the ridge (supinator ridge), then descends inwards posteriorly.

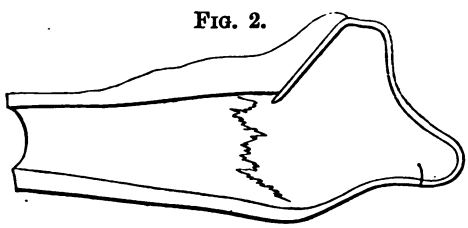
The lower end of the upper fragment is thus left convex from within outwards, and as the fracture is higher behind than in front, it is also convex

from before backwards, whilst the lower fragment is concave. This form of the fragments conduces to the displacement upwards, outwards, and backwards, of the lower upon the upper fragment.

An examination of the lower end of the radius affords a satisfactory explanation of the course taken by this fracture. Internally it presents an articular surface for the head of the ulna, above which is a small triangular surface, ending in a ridge. The compact tissue forming this small surface is at right angles to a force acting from before backwards, or from behind forwards. Externally is the styloid process, and from its base proceeds another ridge, which I shall call the supinator ridge. It extends upwards, losing itself on the convex surface of the outer border of the radius. Posteriorly there are other ridges. These ridges, with the prominences in front, strengthen the lower end in such a way that we might almost anticipate the direction which the fracture would take from force applied in the manner to be presently mentioned. If we commence posteriorly, and draw a line along these ridges where they join the remaining compact tissue of the body of the bone, it would present a well-defined convexity, indicating the weakest part of the bone, and that in which the fracture often occurs. In front the line taken by the fracture will also be somewhat convex. The lower end of the upper fragment will be convex in front and behind, whilst the upper surface of the lower fragment will be concave. In some cases of fracture there is an obliquity from before, backwards

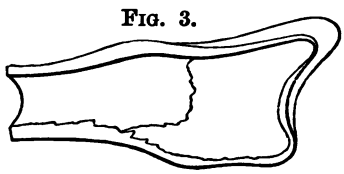
and upwards, as well as from within, outwards, backwards, and upwards, which favours a corresponding displacement of the lower upon the upper fragment, with a simultaneous change in the aspect of the carpal surface.

FIG. 2.



A not uncommon form of fracture is oblique from within, outwards and upwards, as well as from before, backwards and upwards. In this

FIG. 3.

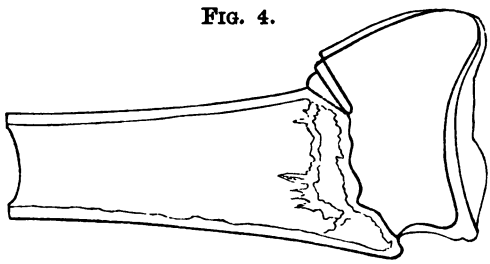


variety the displacement of the lower fragment, upwards, outwards, and backwards, is very easily effected.

A very common form of fracture is that in which there is no displacement of the fragments past each other. At the seat of fracture they are interlocked, and move easily upon each other, as if on a common centre. Figures 2 and 3 are taken from Dr. Smith's work, and illustrate very well

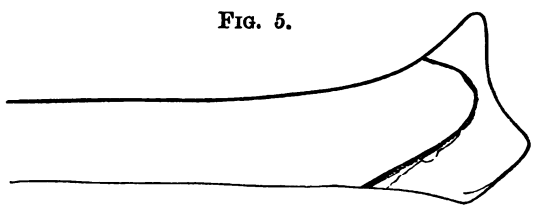
the peculiar characters of the displacement.* The displacement of the carpal end backwards and

FIG. 4.



outwards is greater, and the fracture higher than in the preceding forms. It entails greater deformity, and greater impairment of the functions of the

FIG. 5.



limb, and requires on the part of the surgeon greater care in its treatment.†

This figure (Fig. 6) shows an oblique fracture through the compact tissue in front from within,

* See R. W. Smith, Op. cit., pages 149 and 161.

† Fig. 5 represents a vertical section of the radius through its inner prominence. The curved line shows the direction taken by the fracture (see Fig. 5). Let the reader compare this figure with those numbered 2, 3, and he will see the extent to which the inner prominence of the radius is displaced or rotated backwards.

outwards and downwards; behind it presents an obliquity nearly an inch in length; the lower

FIG. 6.

fragment has moved outwards below, but not above.

MECHANISM.

I think that the greatest misconception still exists regarding the true mechanism of this accident. The patient falls upon the palm of the hand; the impulse received is said to be transmitted through the carpus to the carpal surface of the radius, and, in consequence of the indirect force, the fracture occurs at a variable distance above its carpal end. However, lest I should be mistaken, I submit the two following quotations, as illustrative of the views usually entertained. It is not a matter of mere speculation, but one which will serve to place the characters and treatment of the accident in their true light.

Dr. R. W. Smith says: "The fracture is usually the result of a fall upcn the palm of the hand, and is liable to happen whenever a person in the act of falling forwards throws out before him his arms and hands in a state of extension, which he does, as it were instinctively, to save the head and face from injury. Under these circumstances (if luxation of

the bones of the forearm, at the elbow joint, does not occur), from the influence, upon the one part, of the weight of the body and impulse of the fall, and upon the other of the resistance given to the hand by the ground, the radius, which receives almost the whole force of the shock, breaks at its weakest part, that is, its lower extremity, for it is here that the cellular structure is most abundant, and the compact tissue thinnest. The carpus escapes uninjured, owing to the number of its articulations, which, as it were, divide and decompose the shock, and it is further protected by the palmar fascia, and by the numerous tendons which traverse the front of the carpus." *

Mr. Flower says: "Excepting perhaps the middle of the clavicle, there is no single point of the skeleton so frequently the subject of fracture as the lower end of the radius; the reason being that in falling down the hands are generally thrown forwards, and the whole weight of the body received on the palmar aspect of the carpus, from which it is directly transmitted to the broad articular surface of the radius; this bone, placed thus between the weight and momentum of the body in falling on the one hand, and the resistance of the ground on the other, gives way at its weakest point, where it commences to expand into the broad articular extremity, composed of cancellated tissue covered with a compact layer much thinner than that of the shaft." †

* Op. cit., "Disloc. and Fract.," page 134.

† Flower, "Holmes's Surgery," vol. ii. p. 552, 1st ed.

If the impulse was received upon the carpal surface of the radius through the carpus, the fracture would probably radiate from the point struck. I have carefully examined the carpal surface of the radius in twenty-seven specimens, but I find no evidence of this, and as the fracture is sometimes found only a few lines above the carpal surface, it may be, I think, justly inferred that the force has neither acted from below upwards, nor from above downwards, but transversely, or at right angles to the axis of the radius.

It is generally admitted that a fall on the palm of the hand is the cause of Colles's fracture. How does the force act? To give a satisfactory answer to this question, it will be necessary to direct our attention again to the lower end of the radius, which in front is surmounted by two prominences, with an intervening depression corresponding to the ridge on the carpal surface and to the articulation between the scaphoid and semilunar bones. The inner prominence in the normal radius stands nearly half an inch in advance of the plane of the shaft, giving to the lower end its concave form in front. Now, in all the old specimens of Colles's fracture which I have seen, the inner prominence is displaced so much backwards, as to be almost on a level with the plane of the shaft, and in some cases even behind it. (See Figs. 1, 2, 3, 4.)

The effect, then, of the force producing Colles's fracture, is an almost complete obliteration of the concavity of the radius. The lower fragment is

carried backwards by a rotation or twisting, rather than by a direct displacement backwards.

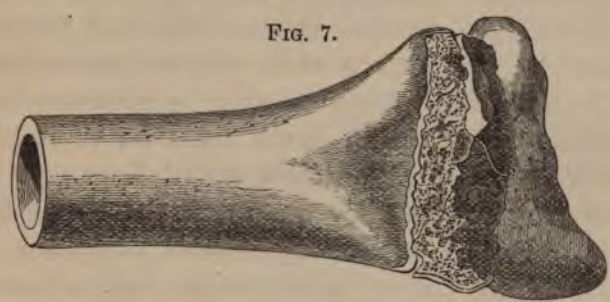
And I, for a short time, supposed that this rotation or displacement backwards of the lower upon the upper fragment resulted from the fall, the extremity being fully extended, acting, in the first place, upon the upper part of the palm of the hand, and then upon the inner prominence of the palmar surface of the radius.

That an impulse received on the inner prominence of the palmar surface of the radius was necessary for the production of Colles's fracture, was soon destined to receive a very rude shock. An engineering student, whilst skating, fell sideways and fractured the right radius, about half an inch from its lower end behind. He positively assured me that the extremity, at the moment of the accident, was not much extended, and that the entire shock was received upon the inner and upper part of the palm of the hand. Then the question again arose—How did the force thus applied fracture the radius? Was it by forced extension of the hand acting, as Mechanics say, by a "cross-breaking" strain? I soon resolved to test the matter by experiment. Selecting in the dissecting room the extremity of an aged subject, I placed my left hand firmly upon the lower end of the back of the radius, with the right I seized the hand, bent it forcibly backwards, when the radius broke easily, and the fracture thus produced was similar to several of the old specimens in the College collection. Several of the students who were present, observing the

ease with which the fracture was produced, soon began to experiment on the extremities which they were dissecting; and in a very short time all the more important varieties of Colles's fracture were represented by artificial ones.

Fig. 7 represents the artificial fracture. The lower fragment has been pressed backwards to show

Fig. 7.



the form of the broken surface. It would require no great stretch of the imagination to predict the effects of muscular tension on the lower fragment. It would have been displaced outwards and upwards, as in Fig. 1, to which it is similar in all respects, excepting that the one is an old and the other a recent fracture. When I press the lower fragment forwards, so as to restore perfectly the natural concavity of the radius, it requires flexion of the hand to an angle of 45°. When I press the lower fragment upwards, even to the small extent of a line, I cannot restore it to its natural position from the resistance offered by the cancellated tissue of the upper fragment. The practical lesson to be learned from this fact is of the highest significance.

A patient presents himself several days after the accident, in whom the lower fragment has become displaced only slightly upwards; under such circumstances it would require extension to bring the lower fragment downwards, to enable us to rotate it forwards into its place, and that rotation will not be accomplished until the hand is flexed, as I have already said, to an angle of 45°.

This simple experiment places the true nature of Colles's fracture before us in such a clear and intelligible form, that it can scarcely be misunderstood. The fall upon the palm of the hand forces it backwards. Putting the anterior carpal ligaments and flexor tendons violently on the stretch, wrenching off by the "cross-breaking strain" the lower end of the radius, tilting it backwards, with alteration of the aspect of its carpal surface, and the bearing of the carpus upon it, leaving a gap between the fragments in front.

The lower end of the upper fragment is convex from within outwards and from before backwards. The lower fragment is concave from within outwards and from before backwards. The upward pressure of the carpus on the latter, which is tilted over, holds it backwards or is applied mainly against the posterior part of its carpal surface. The lower fragment is then retained by muscular action in its unnatural position, and to correct this displacement, the upper fragment must be fixed, the lower pressed forwards, and the hand flexed almost to an angle of 45°. This degree of flexion

is necessary to tilt or roll over the lower fragment into its place for the restoration of the concavity of the radius and the natural aspect of its carpal surface.

Besides, all upward and outward pressure of the carpus upon the carpal surface must be removed and transferred inwards. My improved radial splint, if properly applied, fulfils all these indications.

TREATMENT.

It seems strange that the means too frequently adopted for the treatment of this accident, are not in accordance with true anatomical principles; or I should rather say, the indications for correct treatment have been overlooked. Dupuytren maintains the hand adducted by means of an ulnar splint. The pistol splint so much in use, but variously modified, acts in the same manner. Adduction seems, therefore, to have been regarded generally as of paramount importance. Some have treated it by a front and back splint, maintaining as best they could a sort of imaginary permanent extension. But all these means having been found unsatisfactory, a general consent has been accorded to the correctness of the statement made by Dr. R. W. Smith:

"This sequela of the injury is a source of great inconvenience to the patient and the surgeon, who is afterwards unjustly blamed for its occurrence. The

practitioner will therefore act with prudence in warning his patient at the commencement of the attendance, that stiffness of the wrist-joint and an incapability of flexing the fingers during a period of several months, are by no means infrequent results of a fracture of the lower end of the radius." *

I am happy to state that the results obtained by the use of the radial splint, more especially by the improved form of it, have enabled me to prevent those disastrous results which Dr. Smith describes as the "inevitable sequelæ" of the accident; and if proper attention be bestowed during the treatment, Colles's fracture will not entail consequences more serious than those of any other fracture of the forearm.

For many years I have had no doubt that the failure of the pistol splint was due to the non-restoration of the natural form of the radius, and that the inflammatory swelling of the hand and wrist joints was not a primary but a secondary condition and referable to the same cause. I affirm that when the natural form of the radius is restored immediately after the accident, the "inevitable sequelæ" are seldom observed, and must be regarded as exceptional. The production of the artificial fracture by forced extension shows that the fracture cannot be treated successfully by the pistol splint nor by any other apparatus which holds the hand extended. When I apply the pistol splint to the back of the hand and fore-arm the fragments gape in front, the carpal surface still maintains

* Op. cit., p. 139.

its downward and backward aspect, the carpus presses unnaturally backwards upon it, and the gaping is still further increased when the hand is adducted. Matters are not improved but made worse when the splint is applied to the front of the fore-arm and hand. Neither the pistol nor the straight splint fulfil the indication required of them. They cannot correct the deformity. They cannot tilt or rotate the lower end of the lower fragment sufficiently forwards to restore the concavity of the radius and the natural aspect of the carpal surface. A curved back splint, with a thick pad resting on the base of the metacarpus, the carpus, and the lower end of lower fragment, are required.

The reputation of the radial splint has suffered from its misapplication.

It has been applied so low that the bevelled portion is brought in contact with the carpus and the lower fragment, which are thus held tilted backwards. Unsatisfactory results have followed; the splint was condemned and discarded as no better nor even as good as the other appliances. But this I do not consider as strange, from the very imperfect knowledge of this common accident possessed by those who profess to teach others regarding it.

ADDUCTION OF HAND, PERNICIOUS EFFECTS FROM.

One of the most characteristic displacements of this fracture is that of the lower fragment upwards, outwards, and backwards upon the upper fragment;

and if I were asked what is the best position of the hand to effect this, I would unhesitatingly say, Adduction. *When I adduct the hand, the carpus moves outwards, is applied against the outer part of the carpal surface and the styloid process, and the abductor muscles are made tense.* The advocates of adduction suppose that by drawing the styloid process downwards and inwards the upper end of lower fragment would be carried outwards, and the interosseous space restored. Such reasoning is very plausible, but will not bear investigation.

Of nineteen specimens of Colles's fracture in which both bones of the fore-arm are preserved, in ten the interosseous space is normal, and in the remaining nine it is only slightly diminished. The specimens with the greatest diminution of the interosseous space are those in which the fracture took place more than an inch above its carpal border. These are the cases which are most difficult to manage, and followed, if neglected, by the greatest deformity.

The lower end of the radius is prolonged into the styloid process broad and strong at its base, and the carpal surface is oblique from below, upwards and inwards. This conformation is admirably adapted for the prevention of displacement of the carpus upwards and outwards. Whenever I intend to exert great muscular power, as in lifting heavy weights, I first adduct the hand and then exert my strength. A firm support such as that afforded by the styloid process, with an obliquity of the carpal surface from below, upwards, and inwards, is necessary. We could not

without this conformation exert half the power of which we are capable without incurring the risk of a dislocation upwards and outwards. *The effect, then, of adduction in the treatment of fractures of the lower end of the radius is to produce displacement outwards and upwards of the lower fragment,—the most marked deformity of the accident.* It places the carpus against the outer part of the carpal surface of the radius and puts the abductors in a state of tension, enabling them with the flexors and extensors to pull most powerfully the lower fragment upwards, outwards, and backwards. These remarks are I think sufficient to show that the pistol splint, the ulnar splint of Dupuytren, or any other splint which holds the hand adducted, must fail, aggravating the deformity and placing the hand in such a position that its muscles can act most powerfully in dragging the lower fragment outwards, upwards, and backwards, producing that which it was the intention of the surgeon to counteract.

ABDUCTION.

In abduction the hand moves outwards and backwards, the carpus inwards, slightly forwards: its upward pressure is thereby removed from the outer to the inner part of the carpal surface of the radius.

When I sit down with my arms resting upon a table I see the hand slightly abducted and flexed, the carpus has *moved inwards, making no pressure*

whatever upon the outer part of the carpal surface of the radius. Slight abduction is the physiological position of rest, that in which very few movements of the hand are executed, and that which should be selected for the treatment of this fracture.

ULNAR PORTION OF SPLINT.

At the present stage of the inquiry I shall direct the reader's attention to the ulnar portion of the splint and its action. (*See* Fig. 9.) Its lower end is hollowed externally to receive the inner margin of the hand; there is a slit in its centre of sufficient length to allow the passage of the carpal strap. A piece of spongio-piline or other soft material is placed in the hollow to protect the inner border of the hand from pressure, the carpal strap is passed through the slit backwards, then over the back and outer part of the carpus, and firmly buckled internally. Its action is to press the carpus forwards, and especially inwards, towards the ulna, counteracting the backward and outward pressure of the carpus against the back and outer part of the carpal surface of the radius, transferring it inwards, so as to render the upward pressure totally inoperative. The forward and inward movement of the carpus may be increased by placing two small pads, one on the posterior, the other on the outer surface of the carpus beneath the carpal strap.

A bandage will serve as a substitute for the

carpal strap, but it is more liable to become relaxed. When the carpus is thus bound inwards, the inflammation which results from over stretching of the ligaments and tendons is prevented at the outset.

We may now perceive very plainly, from the changes in the natural relations of parts, and consequently in their actions, that the ligaments and sheaths of the tendons sustain a sort of chronic sprain, which exciting inflammation, ultimately ends in greater or less impairment of the functions of the fore-arm and hand.

That these occurrences are almost entirely referable to the displacement of the lower fragment of the radius,—that every mode of treatment which does not effectually restore the natural form of the radius must necessarily be followed by those distressing consequences which most surgeons have regarded as unavoidable and irremediable,—and that these distressing sequelæ may be almost entirely prevented, I have not the slightest doubt. The treatment of fractures of the lower end of the radius is now, by the proper application of my splint, as easy as that of any other fracture, and unattended with any serious consequences as regards the future usefulness of the limb.

What may be the opinion generally entertained by surgeons as to this inflammatory swelling I cannot say; some seem to regard it as directly resulting from the primary injury. I cannot view it in this light, but as a consequence of the altered relations of the various structures to each other.

The carpus is displaced unnaturally outwards and backwards upon the styloid process and the posterior half of the carpal surface of the radius, stretching the posterior carpal ligaments, the internal lateral ligament and the tendons upon the posterior and the anterior aspects of the ulna. The relations existing between the first and second row of the carpal bones are interfered with, and their ligaments posteriorly put upon the stretch. (*See* Fig. 7.) This is the origin of that inflammatory swelling, and those burning, tingling, pricking sensations, the source of so much discomfort to the patient. No doubt at the moment of the injury the flexors of the ring and little fingers suffer severely from the fracture, by being forcibly driven against the inner prominence on the lower end of the palmar surface of the radius.

This circumstance affords an explanation of the greater flexion stiffness and pain experienced by the patient in these than in any of the other fingers.

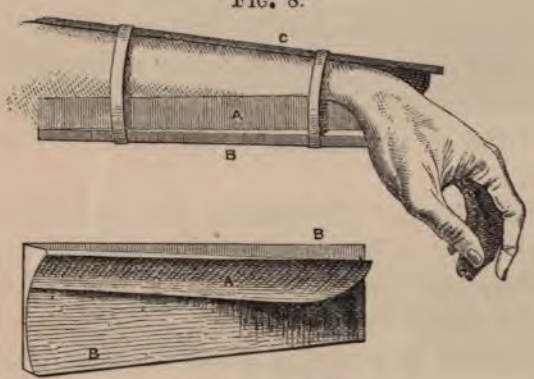
When I examine carefully various specimens of Colles's fracture, I find that the tubercle of the radius looks more forwards than natural, showing that the anterior aspect of the upper fragment is altered; and that the lower fragment is altered even to a greater degree than the upper, seeming as if it had sustained a slight twist backwards upon the former. The abnormally backward position of the styloid process also shows that one of the effects of this accident is to produce abnormal supination of the radius, easily explained by the action of the

abductor muscles displacing the lower fragment upwards, outwards, and backwards.

When the carpus is firmly bound inwards to the ulnar portion of the splint by the carpal strap, it is also rotated forwards or towards the position of pronation, bringing with it the lower fragment, counteracting its unnatural supination.

The addition of the ulnar portion to the original splint is of comparatively recent date. I had a patient in hospital suffering from Colles's fracture;

FIG. 8.



ORIGINAL SPLINT.

FIG. 1.—A, the bevelled piece of the splint applied to the radius. B, the margin of its body projecting outwards and protecting the radius from pressure. C, the dorsal splint and pad.

FIG. 2.—A, shows the form of the bevelled portion; inferiorly it is convex from without inwards, and from before backwards. B, the body of the splint.

the original splint had been applied three weeks, and with the best results. He now began to use the arm too freely, and caused the displacement of the splint outwards.

On its removal I saw that the characteristic deformity of the accident had returned. And as I

was unable afterwards to correct this I resolved to prevent such an occurrence in future, and had a splint made with the ulnar portion attached. This not only effectually prevented the rolling outwards, but by the aid of the carpal strap the tendency to displacement downwards of the whole splint, to which the conical form of the fore-arm conduces so much, was effectually counteracted. I afterwards made a slit in the ulnar portion near its end, through which the carpal strap passes as already described. The splint as at present constructed can neither roll outwards nor be displaced downwards upon the lower fragment, and the bevelled portion is held securely applied at some distance above the lower end of the upper fragment.

In the figures illustrating this splint, as well as in its application, the bevelled portion has been placed too low down. Its office is to fix the upper fragment, which has undergone very little displacement; and it is a matter of no moment whether it rests at half an inch or an inch and a half above the lower end of the upper fragment. The replacement of the lower fragment is effected entirely by the back splint and carpal strap.

Fig. 9. The improved splint may be described in a few words: it consists of the body, the ulnar and bevelled portions, with a curved back splint. The lower end of ulnar portion is curved forwards and hollowed to receive the inner border of the flexed hand with a slit for the carpal strap. The bevelled portion is secured to the body of the splint nearly

half an inch internal to its margin; it is cut off obliquely from without inwards, and from below upwards; it is applied to the palmar surface of the upper fragment. The lower end of the back splint is much curved forwards. This curve, with a thick pad, is necessary to enable it to press the base of the metacarpus, the carpus, and the lower end of

FIG. 9.

IMPROVED SPLINT.

lower fragment well forwards for the restoration of the natural aspect of the carpal surface and the concavity of the radius. In cases in which the fracture is an inch or less above the carpal border, the carpal strap passes over the back splint. Where the fracture is higher than an inch the carpal strap is applied directly over the carpus. The other two straps are then buckled.

The pathological alterations of the lower end of the radius deserve more careful consideration than has hitherto been given to them; they point out the principles on which the treatment should be based.

In consequence of the displacement, outwards and backwards, of the lower upon the upper fragment, the lower end of the ulna becomes unnaturally prominent in front and internally. This is

observed immediately after the accident; but if the primary deformity persists, the prominence of the lower end of the ulna will become more marked, its posterior surface more curved, its inner border more convex, and its head twisted so as to look outwards. The displacement backwards of the carpus on the carpal surface causes absorption of the posterior half of that surface, increasing its obliquity, and giving to it an aspect looking more backwards. This is one cause of the shortening of the posterior surface of the radius.

FIG. 10.

In consequence of the accident the fractured surfaces have suffered more or less contusion, they inflame and soften. The backward pressure of the carpus acting continuously on the fractured surfaces behind, causes interstitial absorption of a large quantity of the cancellous structure of the lower end of the bone.

The outward and upward pressure produces effects even more decided. In one of twenty-seven specimens the styloid process has become almost horizontal and very much thinned, in five it is much absorbed, and in twenty-one it presents various degrees of absorption and displacement backwards; but the most marked displacement is

that of the cancellated tissue outwards, to the extent of three-fourths of an inch in the worst instances. (*See* Fig. 10.) Remodelling of the whole of the cancellated tissue posteriorly and externally, with vertical shortening and transverse elongation, are the effects of the altered bearing of the carpus on the lower end of the radius. The compact tissue in front is not shortened, but it has become more or less convex. Behind, at the seat of fracture, the radius has become concave from the displacement backwards of the lower end of the lower fragment: there a new formation of cancellated bone has taken place, strengthening the bone at the broken part, helping it to resist the upward and backward pressure, and masking the exact course of the fracture behind.

This new deposition of bone behind, with the shortening of the radius externally and behind, have led many surgeons to suppose that these alterations must necessarily be the result of impaction; an opinion which I hold to be now untenable, and which the production of the fracture artificially, controverts in the most decided manner. Colles's fracture is not, nor can it be, an impacted fracture; its mechanism declares impaction to be a mere phantom of the imagination, resulting from the erroneous interpretation of pathological facts.

SECOND FORM OF FRACTURE OF THE LOWER END OF RADIUS.

THIS fracture is comparatively rare. I have seen only two instances of it. In one case a man aged twenty, whilst leading a horse out of the stable, had his fore-arm compressed between the door frame and the side of the animal, the hand being flexed at the time. On examination I found the radius broken about an inch and a half above its lower end; both fragments were displaced backwards and inwards, producing a well marked prominence on the dorsal surface, with an increase of the concavity of the radius; the ulna was prominent internally, the radio-carpal articulation well defined, and the styloid process of the radius elevated. Dr. R. W. Smith, in his description of Colles's fracture, has given two figures illustrating this accident. In that description it appears to me that he has failed to recognize the difference between the two accidents.

SECOND FORM.	COLLES'S FRACTURE.
Cause. — 1. Violent flexion; force applied to the back of the hand from behind, forwards, and upwards.	1. Violent extension; force applied to the palm of the hand from before, backwards, and upwards.
2. Ulna prominent internally from displacement of the carpal fragment outwards.	2. Ulna prominent internally and in front from displacement outwards and backwards of the carpal fragment.
3. Back of hand and radio-carpal articulation unaltered in appearance.	3. Hand projecting abnormally backwards, seemingly elongated; radio-carpal articulation indistinct.

4. The lower part of the fore-arm behind presents a well-marked prominence.	4. The lower part of fore-arm behind presents a well-marked depression.
5. Concavity of radius increased.	5. Concavity diminished.
6. Aspect of carpal surface looks downwards and forwards, and is more horizontal.	6. Aspect of carpal surface looks downwards and backwards, and is more horizontal.
7. Carpus is displaced outwards and forwards on the carpal surface.	7. Carpus is displaced outwards and backwards on the carpal surface.
8. Outer border of fore-arm unnaturally concave.	8. Outer border of fore-arm unnaturally concave.

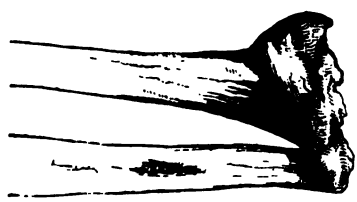
It will be thus seen that these two fractures of the lower end of the radius differ very widely from each other in their causes and signs. The deformity to be corrected is the displacement backwards and inwards of the broken ends. If we use the radial splint it must be applied in a manner very different from that in Colles's fracture.

The carpus is to be bound inwards by the carpal strap or by a bandage. The bevelled portion is to rest against the anterior and upper surface of the carpus and the lower end of the lower fragment. A firm thick pad is placed on the prominence behind; over this the back splint is to be applied, firmly bound by straps or by bandages.

THIRD FORM, OR ARTICULAR FRACTURE OF THE LOWER END OF THE RADIUS.

THE figure below illustrates a very rare form of fracture. There are two specimens of it in Queen's College Museum. A photograph of one of them was taken, and a woodcut made from it. The fragment broken off in each specimen is of the

FIG. 11.



same size, and the only difference between them is the displacement of the one a little higher than the other. The fracture commences internally at the junction of the carpal surface with the compact tissue behind, and passes directly outwards until it arrives at the base of the styloid process; then it ascends, crosses the outer border of the radius, next descending it passes obliquely inwards.

The fragment has on it the whole of the carpal surface, the articular surface for the head of the ulna; and externally the styloid process and the entire ridge on the outer border of the radius (supinator ridge); it is displaced upwards, forwards, and

outwards, over-riding the lower end of upper fragment in front. The carpal surface is horizontal. In one of the specimens the lower overlaps the upper fragment so much that it might be styled an impacted fracture.

I have not met with this accident in the living. The displacement upwards, forwards, and outwards of the lower fragment is so marked as to present signs by which it can be easily recognized. The force causing it must have been applied from behind, forwards, and upwards, carrying the carpal surface with a considerable portion of the anterior and outer part of the lower end of the radius before it, leaving all the compact tissue internal to the interval between the first and second extensors of the thumb uninjured, whilst that external is attached to the broken fragment.

DIAGNOSIS.

Radio-carpal articulation well defined; carpus seemingly shortened. Ulna very prominent, especially behind and internally; lower end of radius behind prominent; carpus displaced outwards and forwards. Styloid process displaced forwards and outwards, and on the same plane as the anterior surface of the shaft of the radius. Concavity of radius much increased.

The displacement of the lower fragment forwards and externally is so marked that the accident might be easily diagnosed by this sign alone.

TREATMENT.

As the lower fragment is displaced upwards, forwards, and outwards, it must be brought downwards, inwards, and pressed backwards.

The radial splint must be applied so low that the end of the bevelled portion shall rest upon its anterior surface. The carpal strap, by holding the carpus inwards, will counteract the displacement upwards and outwards. As the supinator radii longus is inserted into the lower fragment its relaxation, by flexing the fore-arm on the arm, will facilitate very much the replacement.

FRACTURES OF CLAVICLE.

For several years past I have regarded the doctrines taught on the pathology and treatment of fractures of the clavicle as in many respects erroneous. After devoting much time to the careful consideration of the subject, the conclusions at which I have arrived may be briefly summed up in a few words.

1. That the shoulder, though apparently, is not in reality depressed by the weight of the extremity.

2. That there may be a slight depression, due to the scapula falling inwards and forwards upon the thorax.

3. That to push the shoulder upwards, backwards, and outwards must increase the deformity, as this movement deprives the scapula of the support of the thorax.

4. That the only requisite condition in the treatment is to rotate the shoulder outwards and backwards, and maintain it in that position until osseous union has taken place.

5. That the fractures in the outer third of the clavicle, which have been described and figured as external to the coraco-clavicular ligaments, are really in that part of the bone into which the ligaments are inserted.

6. That the inner or sternal fragment of the

clavicle admits of movement in a direction forwards, upwards, or backwards. It is very frequently displaced, and the main cause of its displacement is the action of the outer fragment pushing it forwards and upwards.

I shall commence with the more simple forms of displacement, and afterwards proceed to the more complex.

I have before me a specimen of fracture of the clavicle between the coraco-clavicular ligaments, or, to speak more correctly, in that part of the clavicle into which the ligaments are attached. The fracture is scarcely an inch from its outer end, and the fragment is displaced forwards and inwards, forming almost a right angle with the inner portion. The surfaces of the fragments preserve their normal aspects. When the specimen is placed in its normal position on the thorax, with the scapula attached, the axillary space is found to be considerably diminished. The scapula has, therefore, fallen inwards upon the side of the thorax. The use of the clavicle is to keep the shoulder outwards and backwards; the fracture has led, as it were, to the shortening of the clavicle by nearly an inch, and the scapula having thus lost its outward support has fallen forwards and inwards upon the thorax. To correct the deformity all that is requisite is that the scapula should be rotated outwards and backwards. In this movement it would carry with it the displaced fragment of the clavicle, and restore it to its natural position. A pad in the axilla, by its action on the humerus, would press the shoulder

outwards and slightly backwards, but not sufficiently backwards to rotate the scapula into its place. The clavicular apparatus, which I shall presently describe, may be said to afford us an artificial clavicle, acting in the same direction as the natural one, but placed a little lower on the thorax. It pushes the shoulder outwards and backwards, sufficiently to prevent the shoulder falling forwards and inwards, and to counteract the action of the serratus-magnus and upper sternal and clavicular fibres of the pectoralis major. These are the two muscles which are concerned in the production and maintenance of the deformities in question, the serratus being the more important.

As regards the displacement forwards and inwards of the outer fragment, Dr. R. W. Smith makes the following remarkable statement. He says: "The displacement is principally due to the action of the clavicular portion of the trapezius muscle." * That the fibres of the trapezius which are attached to the outer fragment, and arise from the ligamentum nuchæ, could carry this fragment forwards and inwards, is to me unintelligible: their action would unquestionably be to draw the shoulder upwards, backwards, and inwards; and all that we can affirm of muscles in the matter is, that the forward action is produced by the serratus-magnus and greater and lesser pectoral muscles. In this form of fracture and displacement the use of the clavicular apparatus affords us the most satisfactory results.

* "A Treatise on Fractures in the Vicinity of the Joints," p. 222.

FRACTURE OF THE STERNAL END OF THE CLAVICLE.

I have seen but two instances of that rare form of fracture, in which the posterior part of the articular end is broken off from the anterior.

In the second case, which occurred recently, the patient was a female who had fallen down-stairs, and was brought into the hospital shortly after the accident. The sternal end, displaced inwards and downwards upon the sternum, formed a tumour much smaller than that which would have been produced by the entire sternal end. I therefore examined the cavity from which the displacement had occurred, and was able to detect the detached posterior fragment. The clavicular apparatus was applied, and the anterior fragment resumed its place. The only difference between the two sides was that the injured side was a little fuller and more prominent than the opposite one. This sort of case resembles and might be mistaken for a dislocation forwards and inwards of the sternal extremity of the clavicle, but the diagnosis may be easily made by the smaller size of the tumour on the sternum, and by feeling the smaller posterior portion in its natural position. The diagnosis is, however, of little moment, as the treatment is the same in all fractures of this bone. A case was mentioned to me some time ago by Dr. James Hill, of Belfast, now of Reigate, in Surrey. The patient, a strong muscular man, had the sternal end of his clavicle dislocated backwards and inwards. The

knee was placed between the shoulders, and the shoulders were drawn backwards. The clavicle resumed its natural situation, but immediately became dislocated when the extension ceased. Dr. Hill had the man conveyed to hospital, where attempts at reduction were again made without and with chloroform, but ineffectually. The clavicular apparatus was applied, and on the following morning the dislocation was found reduced, and the apparatus maintained the bone in its place until the lacerated ligaments had united.

A short time before the admission of the before-mentioned case of fracture of the clavicle, a middle-aged man presented himself at the extern department of the hospital with a fracture of the clavicle, caused by direct violence, which was interesting not only from the seat of fracture but also from the peculiar displacement. The outer end of the inner fragment projected the skin and looked directly towards the angle of the jaw. The outer fragment was displaced inwards and downwards. The head was bent forwards, and the sterno-mastoid muscle was so much relaxed as to lead me to suspect that the displacement upwards of the inner fragment could not be caused by that muscle. The clavicular apparatus was applied, the outer fragment was carried outwards and backwards, and on a very slight touch of the finger the inner fragment resumed its place. On the following morning the deformity had returned, as the rod which connects the arm-splint with the body-piece had become relaxed; the outer fragment was

again carried outwards and backwards, and the deformity disappeared. It might have been supposed that the displacement upwards of the outer end of the inner fragment was caused by the action of the sterno-mastoid muscle, but this was proved on two occasions not to be the fact. It was the displacement of the outer fragment downwards and inwards which pushed the inner fragment upwards. As regards the displacement, or rather the non-displacement of the inner fragment in fractures of the clavicle, there is a remarkable agreement among surgical authors, from which I entirely dissent. "The outer extremity of the inner fragment appears to be elevated, the skin being drawn tensely over it; but this is rather owing to the depression of the outer portion of the bone; it is, in reality, kept fixed by the antagonism between the sterno-cleido-mastoid and great pectoral muscles." *

In the case just related it was the outer which pushed up the inner fragment, the displacement being caused in this direction by the action of the serratus-magnus and pectoralis major and minor muscles. The mobility of the clavicle forwards, upwards, and backwards has been overlooked by practical surgeons, and has led to a mis-interpretation of facts, and also to false reasoning, and the construction of numerous appliances, variously modified, on false principles. To this I mainly attribute the failure of most mechanical contrivances constructed for the treatment of fractures of the clavicle.

* Erichsen, "Science and Art of Surgery," 4th ed. p. 253.

If I place my hands behind my back, and draw my shoulders as far back as possible, I find that my clavicle has been approximated to the thorax. If after that I extend my arms horizontally forwards as much as possible, I find that the clavicle has advanced also. In these movements that portion of the axillary space which lies behind the clavicle is increased or decreased in proportion as I carry my arms forwards or backwards. If the shoulder be elevated the scapula is also raised off the thorax, and the depth of the axillary space increased or diminished according as the shoulder is elevated or depressed; and if we watch the scapula during these movements, we shall see that its posterior border glides along the walls of the thorax. It must, therefore, be admitted that whatever may be the extent of the natural movement of the clavicle an amount of displacement equal to that movement, or even greater than it, may occur after fracture. Thus, as in the case last mentioned, the inner fragment may be displaced either upwards or forwards by the outer fragment getting behind or below it, quite independently of the muscles acting on the inner fragment. I must, however, refer to this subject subsequently.

Fractures of the clavicle offer no exception to the general law of displacement, which is scarcely alluded to by surgical authors, viz.: That the form of the bone and the direction of the force determine the kind of fracture and displacement in the direction of the axis of movement. Thus if a long bone, such as the femur or tibia, be broken obliquely from

before, backwards and downwards, the lower fragment will project upwards and forwards; if it be broken obliquely from below, backwards and upwards, the upper fragment will project forwards, and the lower fragment backwards and upwards. If it be broken obliquely from within, downwards and outwards, the lower fragment will project upwards and inwards; if the femur be broken from without, inwards and downwards, the lower fragment will project outwards and upwards. These examples show that any particular kind of displacement is due to the form of the fracture rather than to muscular action, which would be nearly the same in these four examples, in which the different form and direction of the fractures determine the different forms of displacement.

Let us now take as an example the most common form of fracture of the clavicle at the junction of the outer with the two inner thirds of the length of the bone. This fracture is usually oblique from before, backwards and inwards.

A lad aged sixteen sustained a fracture of the clavicle at the junction of its inner two-thirds with the outer third. The inner fragment stood out boldly in relief, its end visibly projecting the skin; the shoulder was seemingly much depressed, the arm was approximated to the side, and the elbow supported and steadied by the opposite hand. The head was inclined to the injured side, and the cervical and lumbar vertebræ presented curves whose concavities looked in the same direction. Several students being with me, at the time, I asked if they would be

surprised to find that the shoulder was not really but only seemingly depressed. One of them replied with a smile: "If it be not depressed it looks very like it." The patient was stripped of his clothes, and when his shoulders were denuded the appearances were unaltered, and he supported the arm in the same manner as before. I said, "If there be any depression in this case it is more apparent than real." I then directed the attention of the students to the cervical and lumbar regions of the spine, looking at the patient from behind. It was the left clavicle which was broken. Placing my left hand on the left side of the head, and my right hand on the right lumbar region, I made gentle pressure, and the patient yielded to the pressure, until I had straightened the spinal column; and it was apparent to all that as the curvature disappeared so did the depression of the shoulder, until at length it became a matter of controversy whether any depression of the shoulder existed or not. On looking at the patient in front the appearances were unaltered, the inner fragment stood out boldly in relief; the inner end of the outer fragment lay below and behind the outer end of the inner one, and the point of the shoulder was in advance of that of the opposite side. The clavicular apparatus was applied. A pad, much thicker above than below, was placed in the front arm-splint; the back-splint, with a thick pad, was next applied, and the splints were bound together by a strap tightly buckled and placed as high as possible. At this stage it will be seen that a considerable interval

exists between the lower part of the arm and the splint, and by pressing them towards each other we perceive that the shoulder is carried forcibly outwards and backwards, and that the inner end of the outer fragment is carried outwards and backwards; whilst the inner fragment, no longer pushed up by the outer one, resumes its normal position, and the deformity disappears. By making the pad which covers the front arm-splint much thicker above than below, the lowermost strap may be made to act powerfully in drawing the scapular fragment outwards.

To explain satisfactorily the circumstances just related, I beg the reader's close attention to a few anatomical remarks.

If we divide the clavicle in the dead body at the most common seat of fracture, we can move the inner fragment forwards, upwards, and backwards to a much greater extent than the other fragment; and from this we may fairly conclude that the inner fragment admits of a greater amount of displacement than the outer, whose displacements are scapular rather than clavicular. By this statement I do not mean it to be inferred that the outer fragment may not be displaced to a greater degree than the inner one, for in the ordinary displacement that occurs when the clavicle is broken at the junction of its inner two-thirds with the outer third, the latter is displaced to a greater extent than the former; but this is due to the scapula being displaced forwards and inwards, pushing inwards and backwards the broken end of the outer fragment.

The scapula, by its posterior border, rests upon the ribs behind, and is curved to correspond with the curve of the thorax; the inferior angle is applied to the side of the chest; superiorly and anteriorly it articulates with the clavicle, which, like a beam, supports it, and maintains the transverse breadth of the shoulder, and the integrity of the axillary space. Force applied to the upper and posterior part of the shoulder drives it forwards and inwards. The clavicle receiving the shock is broken at its weakest point—usually at the junction of its inner two-thirds with its outer one-third. To have a correct view of the force thus acting upon the clavicle we must add to the outer concavity the prolongation of the acromion and shoulder. The space between the apex of the shoulder and the sterno-clavicular articulation consists of a convexity formed entirely by the inner two-thirds of the clavicle, and an outer or larger concavity, made up of the concavity of the clavicle and the projection of the shoulder.

The question may now be asked, In what direction would the fragments, in case of fracture at this point, be driven by a force acting on the outer and back part of the shoulder? The answer may be easily given: the inner end of the outer fragment will be driven inwards and backwards behind the inner fragment. We are told, however, that the weight of the upper extremity acting on the shoulder drags it downwards.

Erichsen makes the following statement: "This

displacement is owing to two causes, one of which is mechanical and the other muscular. The displacement downwards is owing to the weight of the arm dragging the fragment down. The displacement inwards, with rotation of the shoulder forwards and pointing of the sternal end of the outer fragment backwards, is owing to muscular action, and is due to the action of the muscles that pass from the trunk to the shoulder drawing the scapula and the whole of the upper extremity forwards and inwards towards the mesial line, when the support of the clavicle is removed." *

The statement that the weight of the arm drags the shoulder downwards, whilst the inner end of the outer fragment is displaced inwards and backwards, and the point of the shoulder is brought forwards and inwards, seems to me to be contradictory, and to be opposed to the general law of displacement in fractures. In the oblique fracture of the surgical neck of the humerus the greatest difficulty which the surgeon has to encounter is the over-riding of the fragments resulting from muscular action. This over-riding is not counteracted by the weight of the arm, and yet we are told that when the clavicle is broken in the situation just mentioned, the whole muscular power of the shoulder is overcome by a weight of a few pounds. The office of the clavicle is to keep the shoulder outwards and backwards, and to afford muscular attachments. By this fracture none of the vertical support has been removed, it is as perfect as before

* "Science and Art of Surgery," 4th ed. p. 253.

the fracture. The displacement of the shoulder forwards and inwards is caused by the serratus magnus behind, the pectoralis major and minor and the subclavius muscles in front. The serratus magnus pulls the scapula forwards, and its lower fibres act on the inferior angle, elevating the apex of the shoulder, and offering in the treatment of fracture of the clavicle the greatest resistance to the adjustment of the broken ends. If the apex of the shoulder were dragged downwards by the weight of the extremity, the inferior angle of the scapula would be rotated inwards and backwards towards the spine. Such a displacement would imply inaction of the serratus magnus, but the displacement of the shoulder forwards and inwards implies action, and this action is opposed to the displacement of the inferior angle backwards and inwards, and is therefore opposed to the depression of the shoulder.

To enable us to support a great weight upon the shoulder there is a remarkable provision. The scapula is placed almost vertically, whilst the clavicle, lying almost horizontally, steadies the scapula. The fibres of the trapezius elevate the apex of the shoulder, and carry it backwards and inwards towards the spine; the serratus magnus draws the scapula forwards, and its lowermost fibres, acting especially on the inferior angle, bring it forwards, and in doing so elevate the apex of the shoulder. The upper sternal and the clavicular fibres of the pectoralis major act in like manner. It cannot be true that the mere weight of the upper extremity is

capable of overcoming a muscular power which in a strong muscular man can sustain a weight not merely of a few but of several hundreds of pounds. The more closely we examine the shoulder the more forcibly are we struck by the wonderful adaptation of muscular power to support weight. What really occurs in fracture of the clavicle is this, that the serratus magnus, acting on the base of the scapula, pushes the apex of the shoulder forwards and inwards, if not upwards. The pectoralis major and trapezius, by a simultaneous action, draw it upwards, the inner action of the former being probably counteracted by the backward and inner action of the latter, whilst the pectoralis minor and subclavius muscles act in approximating the scapula to the thorax, and thus contributing to the backward and inward displacement of the inner end of the scapular fragment. But as the base of the scapula in all its movements is applied to the walls of the thorax, whilst the outer part of the bone is carried inwards and forwards, the axillary space is diminished, and the inner end of the outer fragment is driven backwards, causing great pain to the patient, who brings down his head, bends the cervical region of his spine towards the injured side, and thus relaxes the uppermost fibres of the trapezius. The arm being held a little forwards, and pushed to the side, the muscular action ceases, and the patient suffers less pain. Even when we have placed the patient with his spinal column perfectly straight we may observe an apparent slight depression of the shoulder, from the instinctive yielding towards the injured side, to

lessen the pain caused by the fracture. I do not mean to assert that there is no depression whatever of the shoulder. The shape of the thorax shows plainly enough that when the support of the clavicle is taken away the rotation of the scapula forwards and inwards will admit also of slight depression. The clavicle rests upon the truncated apex of the thoracic cone. The posterior superior angle of the scapula is on the same horizontal plane as the upper surface of the clavicle at the sterno-clavicular articulation. If the scapula be watched during its movement forwards we may observe that the apex descends very little indeed, so little as to never require elevation of the shoulder in any fracture of the clavicle.

When one stands perfectly erect, with the arms pressed against the sides, and attempts to depress his shoulders, he finds that he cannot do it. While in this position let A represent the sterno-clavicular, and B the acromio-clavicular articulation. A B will represent the length of the clavicle, or the radius of a circle of which A is the centre. If we now describe the segment of a circle, and carry B from twenty to thirty degrees upwards from the position of greatest depression of the shoulder, the scapula will ascend, and be removed from the upper part of the thorax. Were the clavicle—the radius of the circle—now broken at the junction of its outer third with its two inner thirds, the inner end of the scapular fragment would fall inwards, downwards, and backwards, the scapula would be approximated to the apex of the thorax,

and although the point of the shoulder were actually elevated the inner end of the outer fragment would be depressed downwards, inwards, and backwards; and it is apparent that the more the shoulder is elevated the more the fragments will over-ride, because of the shortened radius produced, as it were, by the scapula clinging to the apex of the thorax.

I have performed the following experiments on the dead body:—

I divided the clavicle at the point where its anterior convexity terminates, and pushed the shoulder upwards, outwards, and backwards; the inner end of the outer fragment was observed to pass inwards, backwards, and downwards, and great over-riding of the fragments was the result. When I seized the arm and drew it downwards the depression of the inner end of the outer fragment disappeared, and the deformity was much diminished. The reason is obvious: When I pushed the arm downwards the scapula was brought over a wider part of the thorax, increasing the distance between the sternum and acromion process, thus preventing over-riding of the fragments, and the deformity disappeared; and when I pushed the shoulder upwards and backwards the distance between the acromion and sternum diminished, because of the diminution of the breadth of the thorax. We are told that in the treatment of fracture of the clavicle, the shoulder must be raised and supported in a direction upwards, backwards, and outwards.

Now bearing in remembrance the narrowness of the apex of the thorax, the position of the clavicle on its upper and anterior surface, and of the scapula behind, it is quite evident that any elevation of the shoulder will raise the scapula off, and deprive it of the support of the thorax, and contribute to increase rather than diminish the deformity. I therefore regard elevation of the shoulder upwards and backwards as opposed to the true conclusions drawn from the anatomy of the parts, and I believe it will increase instead of diminish the deformity. I have before me two specimens in which fractures of the clavicle had taken place obliquely from without, inwards and backwards, and at nearly half an inch external to their centres. They resemble each other as closely as possible. If I place either of these in its natural situation on the apex of the thorax, keeping the inner fragment horizontal, the outer fragment is depressed to a degree which neither the scapular muscles nor the scapula itself would permit. On first noticing this I proceeded to the anatomical rooms and fractured a clavicle on a recent subject, in the same place as in the two specimens. As the upper surfaces of the fragments were on the same horizontal plane, I pushed the shoulder inwards and forwards, maintaining the same level, and when I had displaced the outer fragment as far forwards and inwards as in the specimens, I found exact resemblance between the artificial fracture and the specimens. The outer fragment elevated the inner one whenever I

brought the shoulder forwards and inwards. I then pushed the shoulder backwards and downwards, and the deformity disappeared.

As fracture of the clavicle, in the situation just mentioned, is attended with greater displacement forwards and inwards than occurs in fracture of any other part of the bone, the outer end is apparently displaced very much downwards, and yet I think it must be conceded that the displacement downwards is apparent and not real, for the following reasons:—

1st. Neither the scapular muscles nor the scapula itself would allow of such an amount of displacement.

2nd. When we place a patient suffering from this displacement on his back, and seizing the arm rotate it outwards, we observe that all deformity disappears. In this manœuvre there is no elevation of the shoulder. If the outer fragment were depressed as much as it appears to be, the simple rotation of the scapula outwards and backwards would not bring the fragments accurately into their natural position. Yet this is a fact which has been long recognized and assented to by all surgeons, who have nevertheless overlooked the indications to which it points. The explanation is that the serratus magnus and the other scapular muscles becoming quiescent from the position assumed, the mere weight of the shoulder falling backwards brings the fragments into position.

3. If we seize the arm and press it backwards and downwards the deformity will disappear; and

if we apply the clavicular apparatus, which holds the shoulder outwards and backwards, similar results will follow. I have not as yet met with any instance of fracture of the clavicle in which I was unable to bring the fragments into accurate apposition by the adoption of any of these expedients; and the practical deductions at which I have arrived are: 1st. That in the treatment of all the fractures of the clavicle what we have to do is to carry the scapula outwards and backwards, and maintain it in that position until osseous union has taken place. 2nd. Almost the sole displacement is forwards and inwards. The only displacement downwards, that I can admit, is that from rotation of the scapula forwards and inwards, when the outward support of the clavicle is removed; but this depression from rotation, in cases of fracture, will always be counteracted by any apparatus which rotates the scapula outwards and backwards. I therefore repeat, that in the treatment of all the fractures of the clavicle the indications are to rotate the scapula outwards and backwards, and maintain this position until osseous consolidation has taken place.

I have before me many specimens of fractures of the clavicle, in the middle or nearly so. In three of them the fracture is very oblique, the obliquity being more than an inch in extent, and from without inwards, the outer fragment lying directly behind the inner one, the inner fragment being displaced forwards and the outer fragment backwards, the aspect of the surfaces being perfectly natural and

on the same level. Why are the upper surfaces of both fragments in these three specimens on the same horizontal plane? The answer is not difficult. One fragment is displaced directly behind the other. The displacement, therefore, of the fragments is that of the inner forwards and of the outer backwards; and the shortening of the bone, caused by the inward and forward horizontal rotation of the scapula, will be the same as is often seen in the fractures between the coraco-clavicular ligaments. But the majority of cases of fracture in this situation are such that when the outer fragment is drawn inwards beneath the inner one, it tilts it forwards and upwards so that the fragments override, the inner one being elevated by the outer.

That there is no depression of the outer fragment may be very easily proved by the following simple experiment:—Take a patient who has sustained either an old or a recent fracture, in whom the outer fragment is seemingly depressed. Let him stand erect, observing carefully that the spinal column is perfectly straight. Draw a straight line across the chest, at right angles to the mesial one, and parallel to the upper surface of the uninjured clavicle; and when it is carried across the injured side the upper surface of the outer fragment will be found parallel to it, or on the same plane as the corresponding portion of the opposite clavicle; whilst the outer end of the inner fragment will be above the horizontal line, or of that of the opposite side.

FRACTURE OF THE CLAVICLE BETWEEN THE CORACO-CLAVICULAR LIGAMENTS.

By the word 'between' I mean a fracture in any part of the clavicle, extending from the innermost attachment of the conoid to the outermost insertion of the trapezoid ligament.

I shall not attempt to give an historical account of the anatomical errors prevalent regarding this common accident.

Dr. R. W. Smith says:

1. "When the clavicle is broken between the coraco-clavicular ligaments there is seldom, if any, displacement of either fragments, and always much less than in fracture of any other portion of the bone."

2. "When displacement does occur it is usually limited to a slight alteration in the direction of the bone, by which the natural convexity of this portion of the clavicle is increased."

3. "In cases of fracture between the trapezoid ligament and the acromio-clavicular articulation the displacement of the outer fragment is in general considerable, its inner extremity being drawn upwards."

4. "This displacement is frequently carried to such an extent that the fragments form a right angle with each other; and it is principally due to the action of the clavicular portion of the trapezius

muscle."* Erichsen says: "Where the bone is broken between the conoid and trapezoid ligaments there is little, if any, displacement, but pain on pressure, some crepitus on moving the shoulder, and slight irregularity on running the finger along the bone. When the fracture is external to the trapezoid ligament there is a remarkable oblique displacement of the scapular fragment, the articular surface of which is turned forwards and inwards, with a slight inclination downwards, nearly at right angles to the rest of the bone, apparently by the dragging of the weight of the shoulder the point of which with the scapula rounded forwards."† Fracture of the clavicle in its outer end is a very common accident, forming about 25 per cent. of the total number of fractures of the clavicle.

In the museum of Queen's College, Belfast, there is an excellent collection, both in number and variety, of these fractures; many of them I dissected, and found that *in none was the fracture external to the extreme insertion of the trapezoid ligament.* I unhesitatingly affirm that in the figures given by Dr. Smith, the seat of fracture was not external to the trapezoid ligament and between it and the acromio-clavicular articulation. I believe that a specimen of such a fracture has yet to be observed and described, as the trapezoid ligament is attached nearer to the end of the clavicle than the fracture in the specimens figured by Dr. Smith, or in any in Queen's College Museum. In most of the college

* "A Treatise on Fractures in the Vicinity of Joints," p. 222.

‡ "Science and Art of Surgery," Erichsen, 4th ed.

specimens portions of ligament have been left attached to each fragment. Neither the conoid nor trapezoid ligaments seem to have offered resistance to the displacement of the outer fragment forwards and inwards. To put this matter to the test of experiment, I sawed through the clavicle to such a depth as to leave the ligaments uninjured, and then breaking the remaining thin layer of compact tissue, I found that these ligaments offered but little resistance to the displacement of the outer fragment forwards and inwards, and that the injury to the ligaments was simply a laceration of the areolar tissue which connects their fasciculi.

In specimen No. 1, the scapular fragment is a little more than an inch in length, and united almost at right angles to the inner one: the aspect of its surfaces has suffered no alteration whatever: the sole displacement is inwards and forwards.

In specimen No. 2, the fracture is $\frac{7}{8}$-inch in its upper surface and $1\frac{1}{4}$-inch inferiorly. It is displaced so much inwards and forwards as to rest upon the anterior border of the sternal fragment, with which it has formed a false joint, leaving the outer end of the inner fragment projecting $\frac{5}{8}$-inch beyond it. Portions of ligament are attached to each fragment. The patient from whom this specimen was obtained was a repairer of chimney tops.

In specimen No. 3, the scapular fragment is $\frac{5}{8}$-inch in length, united at right angles with the inner fragment, the fracture being between the ligaments. The scapula, the ligaments, and nearly

the whole of the clavicle being preserved. The outer fragment is on a plane fully $\frac{1}{8}$-inch higher than that of the inner fragment.

Specimen No. 4 is nearly the same as No. 3, excepting that the scapular fragment is a little larger and rises a little higher, and *points very distinctly to an elevation rather than depression of the shoulder.*

In specimen No. 5, the scapular fragment is $\frac{3}{4}$-inch in length, and is displaced inwards and forwards on the anterior border of the inner fragment. No osseous union existing between the fragments, deposits have taken place on the anterior and posterior borders of the outer fragment, so as to increase its breadth to $1\frac{1}{2}$-inch where it rests on the border of the inner fragment.

In specimen No. 6, the outer fragment is $\frac{1}{2}$-inch in length, displaced inwards and forwards upon the anterior border of the inner fragment, the end of which presents an articular facette, which corresponds to a similar surface on the spine of the scapula. The scapular fragment is on a plane above that of the inner fragment: firm osseous union exists between the fragments.

In specimen No. 7, the outer fragment is $\frac{3}{8}$-inch in length, and seems to be comminuted. This might be regarded as a fracture external to the trapezoid ligament, but of this I have great doubt. The bone is very irregular, its depth or vertical diameter is considerably increased, there is scarcely any displacement, and the specimen is an illustration of comminuted fracture of the acromial end of the clavicle.

In specimen No. 8, the fracture is oblique from before backwards, and the scapular fragment is two inches in length: its inner end is displaced backwards and inwards, the outer end of the inner fragment is displaced forwards. This mutual displacement of both fragments is easily perceived when we place the specimen above another clavicle of similar size and length. Both fragments at the seat of fracture are elevated, and the upper surface of the outer one looks upwards and slightly forwards. This is the first instance in which the outer fragment appears to be depressed, and it might be regarded as the first step to that great displacement of the outer fragment which takes place when the fracture is internal to the conoid ligament.

In specimen No. 9, the scapular fragment is $\frac{3}{8}$-inch in length, united at right angles with the inner fragment. The fracture was through the attachment of the conoid ligament: the aspect of the surfaces of both fragments is unaltered. There is also an oblique fracture of the body of the scapula.

In specimen No. 10, the clavicle is broken on its upper surface $1\frac{1}{8}$-inch from its acromial end. The outer fragment is displaced very much downwards, forwards, and inwards relatively to the inner fragment, the end of which projects upwards and backwards. The corresponding scapula is extensively broken in its body across the spine near its root, and also through its coracoid process.

These ten specimens unquestionably show that when the clavicle is broken external to the innermost attachment of the conoid ligament the outer

fragment is displaced forwards and inwards; it would, therefore, be idle to consider what influence these ligaments may exert in preventing the scapular fragment being displaced forwards and inwards. We have the practical fact to deal with that such a displacement has taken place, and so far as I have had opportunities of studying this subject the limiting influence of the coraco-clavicular ligaments, as described by one surgical writer after another, even up to the present time, is a mere hypothesis. I do not mean to assert that occasionally a fracture may not be observed in which there is very little displacement, and this want of displacement may appear to be due to the limiting influence of the coraco-clavicular ligaments; but this very exceptional case must not be used to illustrate the effects of fracture at this part of the bone.

As regards the diagnosis of fracture between the coraco-clavicular ligaments, I have little to say. The outer concavity of the clavicle is increased in depth, the length of the bone is diminished by half an inch or more, and the point of the shoulder is in advance of that of the opposite side. As the scapular fragment is displaced forwards and inwards, it carries with it the attached fibres of the trapezius muscle, which, as it were, became wrapt round the outer extremity of the inner fragment, the sharp jagged end of which, wounding the trapezius, causes acute pain. If one suspects a fracture between the coraco-clavicular ligaments, passing the fingers over the seat of fracture behind gives such acute pain as to lead one at once to infer the true nature of the accident.

On the under surface of the clavicle, at the distance of a line or two at the most from its external end, there is a rough transverse ridge, to which the inferior acromio-clavicular ligament is attached externally, and the extreme fibres of the trapezoid ligament internally.

From numerous dissections I have found it is very rare indeed that the trapezoid ligament is not attached to the inner margin of this ridge, an anatomical fact which should of itself be sufficient to show that the fracture external to the acromio-clavicular ligaments has yet to be described, and if described, it will be found to be, as in specimen No. 7, a simple or comminuted fracture of the outer end of the clavicle, to which the extreme fibres of the trapezoid ligament will probably be found adherent.

CLAVICULAR APPARATUS—APPLICATION AND DESCRIPTION OF.

The accompanying woodcut represents the clavicular apparatus applied outside the dress. It consists of a body-plate and artificial clavicle or rod riveted to a front arm-splint; to the anterior border of the latter is attached the second arm-splint. The body-plate rests against the side, fore, and back part of the thorax. Anteriorly and internally it has two knobs, and a screw affixed. The rod or artificial clavicle internally has a slit, which enables it to move inwards or outwards to accommodate itself to the varying size of the patient. Behind are three knobs; to the uppermost is attached the strap which passes

over and in front of the shoulder beneath the axilla, and then secured to the lowermost knob. This strap holds the splint well backwards, preventing its displacement forwards, counteracting the action of those muscles which displace the shoulder forwards and inwards. To the centre of this strap, as it passes in front of the shoulder, is attached a shorter strap, which is buckled to the lower or

FIG. 10.

upper front knob. (*See* Plate.) By this arrangement of the straps the body of the splint is immovably fixed on the chest.

A thick pad, made of soft elastic material, is laid on the front arm-splint, taking care to have it over its upper border. A second pad is now placed beneath the outer-splint, and the arm firmly secured

by the uppermost and lowest straps. Between these two straps is seen a third one; this strap is secured to the middle knot behind, and has a buckle attached to it; it is brought forward then in front and over the arm-splints, and buckled behind. Its office is to pull the arm well backwards and slightly inwards.

The greatest difficulty encountered in the use of this apparatus is from the elevation of the shoulder tilting downwards and inwards the inner end of outer fragment, as well as, by rendering the position of the arm more oblique, it is brought in contact with the upper border of front-splint. The latter difficulty can be easily overcome by thick padding; but the former I tried to counteract by carrying a strap from the splint over the point of the shoulder, but the elevators of the shoulder were not to be overcome, as they raised the whole splint upwards. I can effectually counteract the displacement inwards and forwards, but a slight depression of the inner end of the outer fragment from elevation of the shoulder is as yet what I have been unable to accomplish. Were I able to do this, I should regard the apparatus as perfect. The power with which the muscles act in bringing the shoulder forwards and inwards is much greater than I anticipated. In some cases it requires a week or ten days, or even longer, before the outer fragment can be brought sufficiently outwards to restore the normal length of the clavicle.

In some cases when the apparatus is applied, the normal length of the bone will be immediately restored, in others the fragments will override; but

on the patient retiring to bed, and assuming the horizontal posture, on the following morning the deformity will have disappeared. In a third class the fragments still over-ride, the patient complaining of the great pressure on the front of the arm; yet by increasing the thickness of the front pad, and by tightening the back strap day after day, the tension exercised by the apparatus will ultimately overcome the muscular resistance and over-riding of the fragments. In the application of this, as in other appliances, it requires a little practice to master the minor details. The apparatus, when applied, will be found to be in the same state, even at the end of a week, as when the surgeon left it. Sometimes there is trivial swelling of the hand, but in the many instances in which I have used it I have never found it necessary to bandage the arm or fore-arm, as there is no pressure on the vessels or nerves on the inside of the arm. I have, however, applied a third pad and splint over the back of the arm, to guard more effectually against the possibility of pressure on the inside of the arm. By fixing the arm securely to the side, it affords great relief from pain, and enables the patient—as it can be applied outside the dress—to move about freely at the end of the first week.

The clavicular apparatus will be found as effectual in the dislocations as in the fractures of the clavicle. It will also be equally serviceable in the fractures of the upper end of the humerus and neck of the scapula, and in all cases of disease of the shoulder-joint in which it is desirable or necessary to maintain perfect rest. In excision of the head of the humerus it affords great relief from pain.

REDUCTION OF THE RECENT DISLOCATIONS OF THE SHOULDER-JOINT BY MANIPULATION.

My first written communication on this subject was published in the *British and Foreign Medico-Chirurgical Review*, July–October, 1866. Since that period I have practised this mode of reduction with an almost uniform success in hospital, in private practice, and in cases of consultation. In my lectures on surgery in Queen's College, Belfast, I have taught it for the last thirteen years as being the simplest, safest, and least painful mode of reducing the recent dislocations of the upper end of the humerus; and many of my pupils have practised it with great success. During the period above mentioned I have met with more than twenty cases, and in all my anticipations of success were fully realized.

The circumstances which led me to adopt this mode of treatment were as follows:—The patient, a female, in the year 1861, was admitted into hospital suffering from a sub-coracoid dislocation of the right humerus. She was placed on a mattress on the floor, chloroform was administered, and when, as I supposed, complete anæsthesia had taken place, I commenced the reduction by extension outwards, the pain of which, rousing her from her

quiescent state, she became very violent. At this time I was holding the extremity abducted at about an angle of 45° with my left hand. Whilst more chloroform was being administered, with the right, I began an examination of the mobility of the humerus through the axilla. On pressing the humerus forwards, to my surprise, it glided easily into the glenoid cavity.

On reflecting on these circumstances, I determined to imitate the steps which unexpectedly led to the reduction in the next case that presented itself.

In the mean time I carefully studied the action of the various muscles, and their degree of tension in the various positions occupied by the head of the humerus in the different dislocations.

When I place the head of the humerus in its natural position in the glenoid cavity, the coracoid process prevents it passing directly inwards. The long head of the triceps being attached to the lower margin of the glenoid cavity prevents it passing directly downwards. In dislocations the head of the humerus passes downwards and inwards, between these two structures, lacerating at least the inner half of the capsule, and escaping over the margin of the glenoid cavity, it comes in contact with the inner margin of the anterior border of the scapula. If the head of the humerus remains in this position, which it seldom does, it will form the sub-glenoid dislocation. But most frequently when the arm drops, the head ascends until it lies beneath the coracoid process constituting the sub-coracoid dislocation. If the force has driven the head more

inwards, it will constitute the intra-coracoid and the sub-clavicular dislocation. Hence it may be inferred that all the dislocations of the humerus, excepting that beneath the spine of the scapula and the upward dislocation, are varieties of one and the same dislocation, as the head on leaving the cavity must pass primarily between the coracoid process and long head of the triceps muscle; and, also, that the farther the head of the bone is removed from the glenoid cavity the greater will be the injury to the scapular muscles, the capsule, and less will be the resistance offered to the reduction. To understand fully the mode of procedure for the reduction of recent dislocations of the shoulder-joint by manipulation, it will be necessary to take a general survey of the articulation. The glenoid cavity is a shallow depression, slightly deepened by the glenoid ligament—small indeed when compared with the large articular surface of the head of the humerus. The capsular ligament is attached superiorly around the margin of the glenoid cavity, whilst its humeral end is attached beyond the anatomical neck, and its laxity is such that, when the muscles are detached, the head drops considerably. This laxity permits of the greatest freedom in all the movements of the head of the humerus, and when we divide its inner and lower part sufficiently, to permit of dislocation, I can displace the head of the humerus without inflicting any further injury, until the anatomical neck rests against the inner margin of the glenoid cavity, the beak of the coracoid process resting against, or lying above, the middle of the great

tuberosity, the head looking inwards and slightly backwards. If I press the head of the bone firmly, so as to displace it completely over the margin of the cavity into the sub-scapular fossa, the posterior and upper part of the capsule will be found to have undergone a very slight laceration; and when I attempt the reduction by rotating the head of the humerus forwards, it glides easily into the cavity, the capsule offering no resistance.

From this it may be inferred that the capsule alone offers very little impediment to reduction by manipulation; but, to prevent misconception, I do not mean to imply that the capsule cannot offer any impediment to the reduction, for the muscles frequently retain the head in a position in which the capsule may offer great resistance, especially in the reduction by forcible extension. Attached to the tuberosities are the four scapular muscles, and as these processes are removed one inch at least from the glenoid cavity, and are on the outer, posterior, and inner part, they are thus removed from the centre of motion, and enable the muscles attached to them to act as depressors in all the upward movements of the arm. When I raise the arm at right angles to the body, the head of the humerus descends from the upper to the lower part of the glenoid cavity, and nearly the whole of its articular surface is brought in contact with the inner and lower part of the capsule. When force is applied to the upper extremity, in a direction downwards and inwards, sufficient to lacerate the capsule,

the head escapes downwards and inwards; and on the extremity dropping, the dislocation, at first sub-glenoid becomes immediately sub-coracoid, or, as I express it, passes from the first (sub-glenoid) to the second stage (sub-coracoid). Indeed, where the head remains fixed below the glenoid cavity, on the inner margin of the anterior border of the scapula, is an extremely rare form of dislocation, as there is no obstacle to its elevation, whilst we have the deltoid, clavicular fibres of the pectoralis major, coraco-brachialis and short head of the biceps all conducing to it; but the degree of depression or depth to which the head is driven into the fossa will vary in different cases according to the amount and direction of the force producing the dislocation.

The next question that arises is, What is the state of the scapular muscles when the head of the humerus rests in the sub-scapular fossa? The supra-spinatus and infra-spinatus are slightly tense, the teres minor and sub-scapularis muscles are relaxed; and now, when I view as a whole all the muscles engaged in the movements of the scapulo-humeral articulation, they resolve themselves into two sets of stays, the one scapular, surrounding on all sides the head of the humerus—viz., supra-spinatus above, the infra-spinatus and teres minor behind, the triceps below, and the sub-scapularis on the inner side; the long head of the biceps may also be included amongst the scapular stays.

The outer set of stays consists of the deltoid,

pectoralis major, lattissimus dorsi, teres major, the short head of the biceps, and coraco-brachialis muscles. When the head is dislocated it may be easily perceived that a very slight movement of the humerus in one direction will make one set of stays tense, whilst those on the opposite side will be relaxed; and when we examine the subject minutely, a movement of the humerus, even to a few degrees, will be sufficient to produce resistance from tension of one set of muscles or the contrary, it matters little whether the movements be upwards, downwards, backwards, or inwards. Keeping this muscular arrangement in view, a comparison of the methods of reduction by manipulation with those by violent extension, the mischief that has resulted from the latter becomes quite apparent; it may be also perceived that the movements necessary to effect the reduction by manipulation must be done in the gentlest manner possible, and in the proper direction.

The history of the reduction of recent dislocations of the humerus by manipulation may be said to date from the earliest records of surgery, as cases have occurred from time to time in which, from some very slight cause, the reduction unexpectedly occurred. Such cases were regarded as accidental and undeserving of investigation. I have already referred to the circumstances which led me to investigate the matter, and the following modes of procedure have emanated from that enquiry.

FIRST MODE OF PROCEDURE

Is very simple. Suppose the right humerus is dislocated, and the dislocation a sub-glenoid. I place the patient on the left side; then, standing or sitting beside him, I lay hold of the dislocated extremity with my left hand at the elbow joint, the thumb resting against the flexure, and the fingers on the lower end of the humerus and olecranon. I raise the arm at right angles to the body, the forearm being flexed and lying over the thumb and across the chest, the hand almost touching the clavicle of the opposite side. Passing the right hand into the axilla beneath the head of the humerus, I now make the muscles tense by drawing the humerus upwards (as the patient lies) with the left hand, and with the right pressing the head of the bone in the same direction. I thus maintain gentle tension of the muscles until the greater tuberosity of the humerus has passed over the margin, and rests upon the glenoid cavity. With the right hand still pressing firmly, but gently, upon the head of the humerus, felt through the axilla, I thus prevent it slipping from its position; and now, with my left hand carrying the elbow backwards, downwards, and inwards, at the same time pressing with my right hand upon the head of the bone, it glides into its place, and the reduction is effected.

When I first began to practise manipulation I was not aware of the advantage to be gained by carrying the elbow backwards, downwards, and in-

wards. The following incident led to its adoption: In the class of operative surgery, when performing excision of the head of the humerus by the straight vertical incision through the deltoid muscle, and after complete division, as I supposed, of all the scapular muscles, the head of the bone was protruded sufficiently to enable it to be sawn off; I said to the student who was operating that as the head of the humerus projected sufficiently to enable it to be sawn off, that we need not waste time, but proceed to another operation. Whilst this was going on I inadvertently displaced the head of the humerus into the axilla, and then began to pull it upwards and inwards, and upwards and backwards. The replacement was resisted. By carrying the lower end of the humerus backwards and downwards, it glided easily into its place. My attention being thus aroused, I repeated the same manœuvre, with like results. What resists the reduction by pulling the arm upwards? After dismissal of the class I cut across the deltoid muscle, turned it aside, when I saw that resistance was due to a few shreds of the teres minor and capsule, and I also perceived at the same time the great advantage gained by carrying the arm backwards, downwards, and inwards. Before this incident I reduced the sub-coracoid and the sub-glenoid by the same procedure, converting the sub-coracoid into the sub-glenoid. At first I simply kept up the tension of the muscles, carrying the elbow backwards and then bringing it forwards, pressing at the same time upon the head of the humerus; and thus I proceeded, being

often necessitated to give chloroform to enable me to produce that relaxation necessary to lift the head of the humerus over the margin and into the glenoid cavity. When I place the great tuberosity on the margin of the cavity, the head is at least one-third of an inch below its margin, and as the point of tension is greatest when the head is first passing over the margin, almost all the muscles at this stage resist. When, however, I succeed in placing the great tuberosity on the margin of the cavity, and with the one hand depress the lower end of the humerus, whilst with the other I steady the head, which by the movement backwards, downwards, and inwards, is raised, escaping into the cavity by the action of the supra and infra-spinati. I may here remind the reader of the importance of carrying the lower end of the arm backwards, for if it were brought directly downwards the tuberosity would slip off the margin and be again dragged into the axilla ; indeed, the arm should be carried so much backwards that the tuberosity to which the teres minor is attached will come against the cavity immediately above the attachment of the triceps. By this procedure we first raise the arm into that position in which there is the greatest relaxation of all its muscles. The head of the humerus is then raised until its tuberosity rests on the margin of the glenoid cavity, and steadying it by the one hand, whilst with the other we carry the elbow backwards, downwards, and inwards. We thus raise the head and roll it into the cavity, the spinati muscles assisting.

SECOND MODE OF PROCEDURE.

Seizing with the left hand the arm at the elbow joint, the fore-arm flexed, I raise it up until it forms an angle of 45° with the body, inclining the arm slightly forwards and inwards. Then I pass the fingers of the right hand as high into the axilla as possible, and pressing upon the surgical neck of the humerus, I push it forwards from the sub-scapular fossa over the margin and into the glenoid cavity. In one case in which manipulation by the first method had failed, as well as the heel in the axilla, and powerful extension upwards by the pulleys, I succeeded easily by this method. The muscles, however, had been very much relaxed, partly by the prolonged administration of chloroform, and by the action of the pulleys. This was the method by which I reduced the dislocation, which led me to investigate the subject now under consideration.

THIRD MODE OF PROCEDURE.

When I divide on the dead body the inner and lower part of the capsule, the natural laxity of the structures permits the head of the humerus to be easily displaced so much inwards that the greater tuberosity will be over the glenoid cavity, the neck against its margin, and the head directed inwards and slightly backwards. I suspect such cases of partial dislocation are not rare.

The reduction can be easily accomplished by slightly abducting the arm, carrying it a little inwards and forwards at the same time that we rotate the head forwards. By this manœuvre the head of the humerus is rotated forwards and above the margin of the glenoid cavity, when the spinati muscles affect the reduction. When the humerus is forced more inwards, so as to place it internal to the margin of the cavity, the tuberosity is still above the level of the latter. Now when the arm is rotated outwards the head is raised forwards, the tuberosity is brought over or upon the margin of the cavity, and the head elevated. It may be pushed easily into the glenoid cavity by bringing the arm forwards and inwards with the one hand, whilst we use the other as a fulcrum upon the upper end of the humerus. In this manœuvre, whilst bringing the arm across the chest, we must take care that the rotation outwards of the arm, or of the head forwards is maintained; otherwise, the head of the humerus being behind the margin of the cavity and directed backwards, will be prevented from passing into it. When I press the head of the bone still deeper into the sub-scapular fossa, so that the back of the great tuberosity is on or below the level of the margin of the glenoid cavity, then rotation of the extremity outwards or of the head forwards will be of no avail, as this movement will simply cause the humerus to rotate on its axis in the fossa. Under such circumstances the head might be forced forwards by pressure on the surgical neck through the axilla, and if we succeed in forcing it sufficiently forwards,

that the back of the great tuberosity be brought above the level of the glenoid cavity, then the rotation outwards will succeed. It should not be forgotten that the coraco-brachialis and short head of the biceps pass in front of the head of the humerus, and they will therefore resist the rotation forwards. The resistance offered may be very much diminished by their relaxation, which is easily effected by bringing the elbow inwards and forwards, whilst we rotate the head forwards. In two specimens of subcoracoid dislocation in Queen's College Museum, the tuberosity is considerably in front of the level of the margin of the glenoid cavity. I suspect that this is the condition in most cases of this dislocation. Now when we rotate the head of the humerus well forwards, or the fore-arm outwards, its tuberosity is brought over the glenoid cavity, and the posterior scapular muscles effect the reduction.

FOURTH MODE OF PROCEDURE.

Raise the arm at right angles to the body with the fore-arm flexed, as in the first procedure. Make tension forwards until the great tuberosity rises over the margin and into the glenoid cavity, carry the elbow backwards and upwards, and then rotate the fore-arm forwards and outwards. The backward and upward movement of the elbow raises the head of the humerus above the level of the glenoid cavity, the rotation downwards and outwards brings the head of the humerus into it. Indeed, in this move-

ment the humerus revolves upon the great tuberosity as upon a pivot.

If we attempt the rotation before the tuberosity is raised over the margin of the glenoid cavity, it will be suddenly checked by the resistance of the supra-spinatus muscle, for the head being still in the fossa does not rotate upon the tuberosity as a centre, but upon the head and neck as a radius.

FIFTH MODE OF PROCEDURE.

Draw the arm directly outwards across the glenoid cavity, maintaining with the left hand outward tension, and with the right pressing on the head of the humerus through the axillary wall in front. Then slowly and gently bring the elbow forwards and inwards, pressing at the same time the head of the humerus outwards, the head slips into the glenoid cavity. By the first part of this manœuvre the head of the humerus is raised out of the sub-scapular fossa and brought on a level with the glenoid cavity; the pectoralis major and sub-scapularis muscles will be made tense, and offer resistance to the outward movement of the humerus. However, if we can maintain with the right hand the head in its position, on the margin of the glenoid cavity, the resistance from the two muscles just mentioned will become less and less as the lower end of the humerus is brought forwards and inwards. This method I have not tried on the living, but it succeeds very well in the artificial dislocations produced on the dead subject.

It must be remembered that in the recent dislocations of the humerus all movements of this bone are very painful, and excite muscular spasm, especially of the scapular muscles over which the patient has very little control. It will therefore be necessary that all the movements should be done in the gentlest manner possible, slowly and steadily persevered with until the spasm subsides, when the muscles yielding to the gentle traction, enables us to plant the great tuberosity over the margin of the glenoid cavity.

In most cases the spasm, after a short time, will cease, yet in others it persists so long that the administration of chloroform becomes justifiable.

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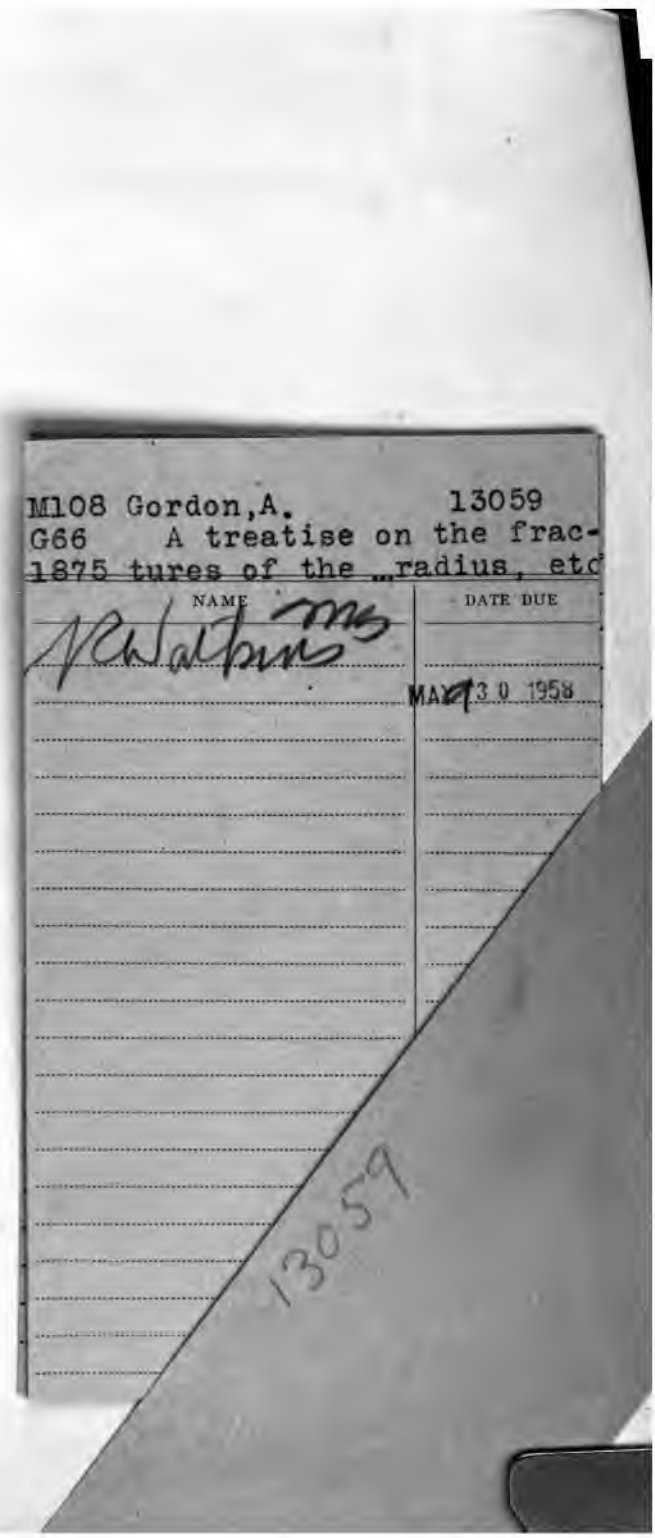
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